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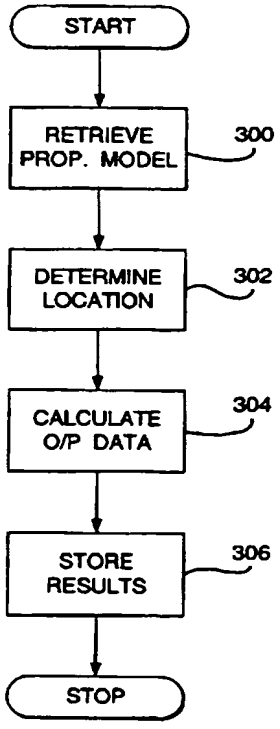
(54) Abstract Title
Verifying signal reception

(57) A propagation model which is agreed between a user and a service provider is stored in the user's mobile terminal. The terminal generates information indicative of the user's ability to receive a signal associated with a service based on the propagation model and the location of the terminal as determined by itself. The information generated by the terminal can be used by both the user and the service provider at a later time to determine the user's ability to receive the service. The arrangement may be utilised in a secure broadcast system in which the user does not wish to pay for a service they were unable to receive whilst in an undisclosed location. Alternatively the signal power received from a plurality of transmitters may be compared against a prediction from a propagation model to determine a level of confidence in the correct operation of the radio receiver, antenna or transmitter.

Fig. 3



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig. 1

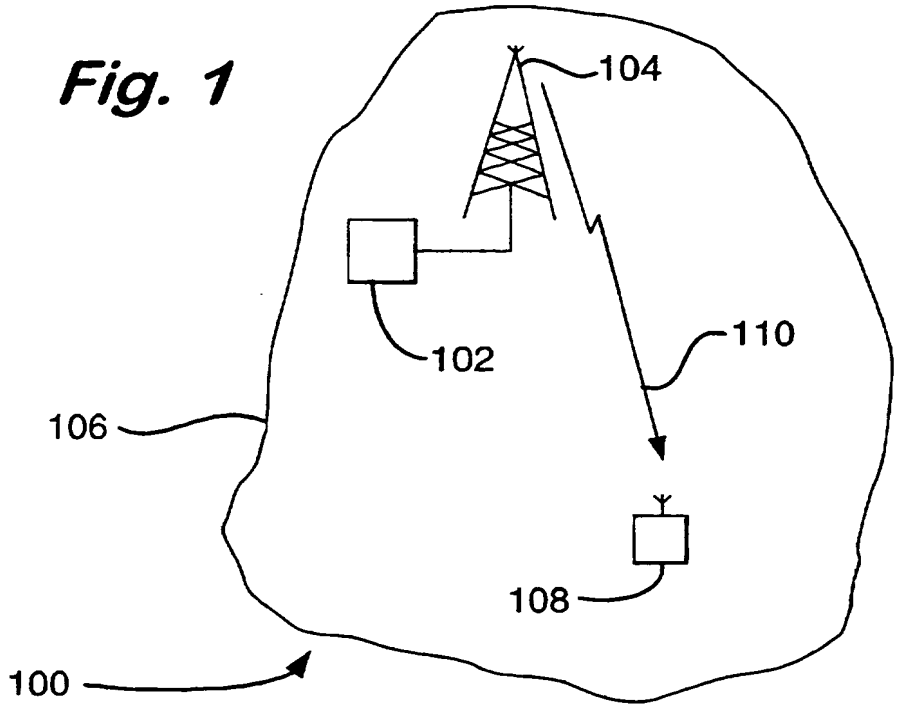


Fig. 2

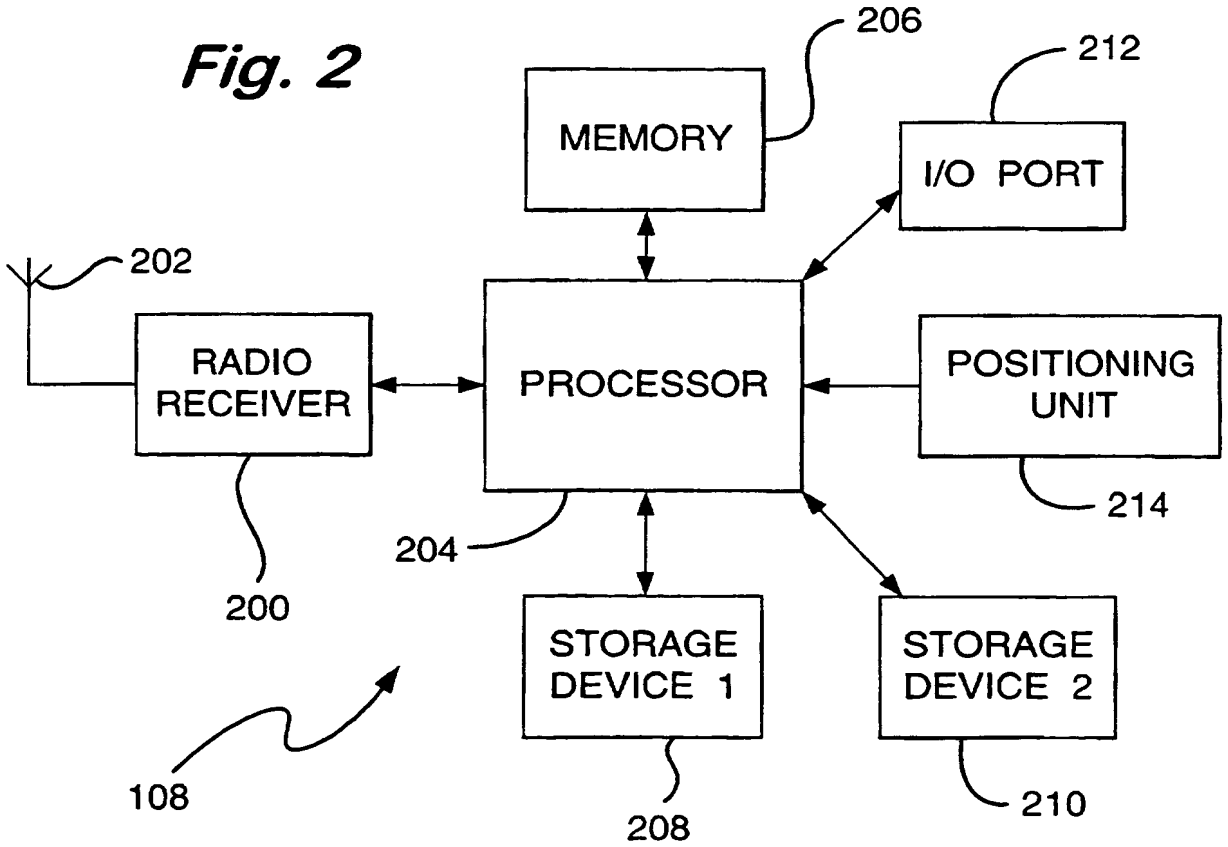


Fig. 3

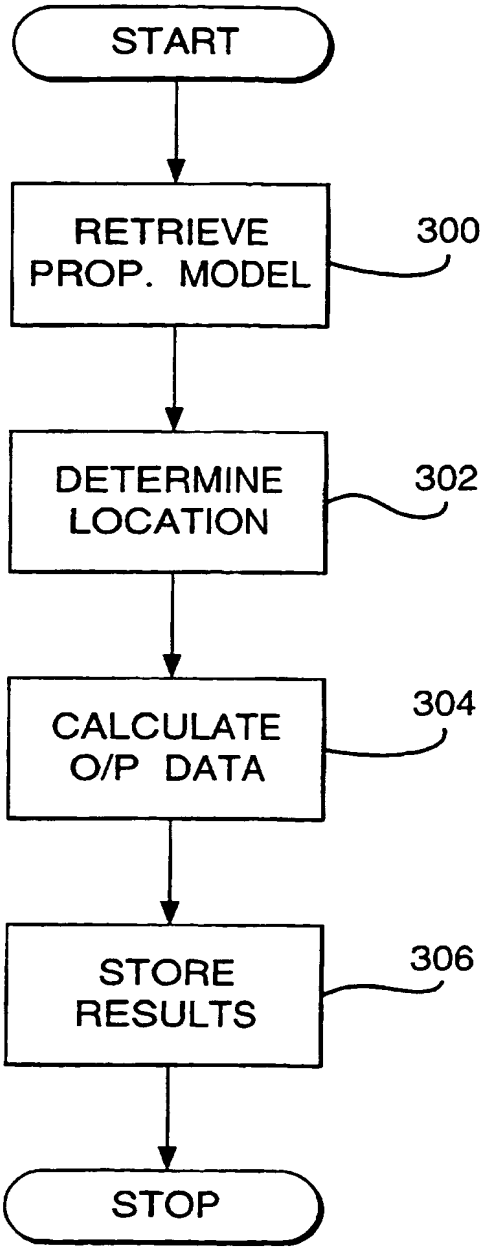
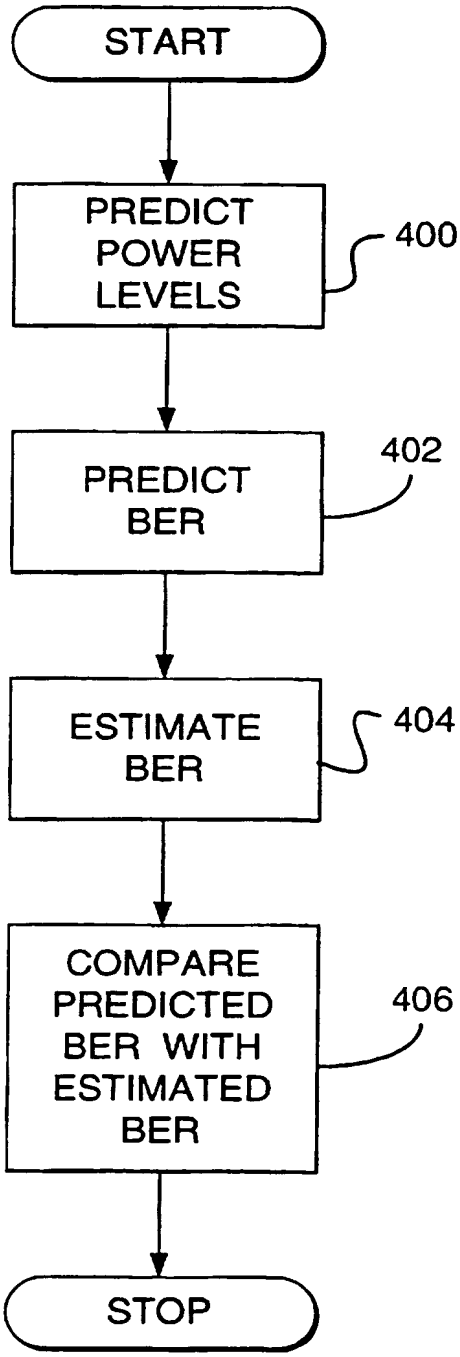


Fig. 4



METHOD OF AND APPARATUS FOR VERIFYING SIGNAL RECEIPT ABILITY

The present invention relates to a method of and apparatus for verifying signal receipt ability in a system where a radio-frequency broadcast is transmitted to a user at an undisclosed location.

In a secure broadcast system, a service provider operates a broadcast radio station providing a received signal service to a user, for example, a broadcast of data messages. The received signal service has an associated coverage area which may be substantially world-wide and the user is equipped with a mobile terminal capable of receiving the received signal service within the associated coverage area. Furthermore, in the secure broadcast system, the location of the user's mobile terminal is regarded as confidential, or secret, for a relatively long time and cannot be revealed to the service provider. Additionally, the user generally only returns from the confidential location to a non-confidential, or non-secret, location after a period of time has elapsed since the received signal service has been used; the elapsed period of time can be days or months.

Typically, the user has contracted the service provider to deliver the received signal service, for which the user will pay the service provider if the service is successfully received. However, if the user alleges that reception at an undisclosed time and undisclosed position was not possible and consequently withholds payment, the service provider has little way of analysing and verifying the situation. Furthermore, at the time the received signal service is being provided, there is no timely return channel between the user and the service provider for providing feedback to the service provider as to the user's ability to receive the received signal service.

It is therefore an object of the present invention to obviate or at least mitigate the above problem of lack of information regarding the ability of the user to receive the received signal service.

According to the present invention, there is provided a method of verifying the ability of a first terminal, at an undisclosed location, to receive a signal transmitted from a second terminal, the method comprising the step of: determining the location of the first terminal at the location of the first terminal, generating data corresponding to an indication as to whether or not the first terminal should be able to receive the signal based upon the location determined at the location of the first terminal, a location of the second terminal and a propagation model corresponding to the communications link between the first and second terminals.

According to the present invention, there is also provided an apparatus for verifying the ability of a first terminal, at an undisclosed location, to receive a signal transmitted from a second terminal, the apparatus comprising location means for determining the location of the first terminal at the location of the first terminal, and data generating means for generating data corresponding to an indication as to whether or not the first terminal should be able to receive the signal based upon the location determined by the first terminal, a location of the second terminal and a propagation model corresponding to the communications link between the first and second terminals.

It is thus possible to provide a method of and apparatus for verifying the ability of the first terminal to receive the signal transmitted by the second terminal, for example, the received signal service, without revealing the location of the first terminal. Additionally, the invention makes it possible to detect something is awry and provides a basis for re-calibration of the propagation model.

At least one embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a typical system arrangement in which an embodiment of the invention is employed;

Figure 2 is a schematic diagram of a terminal for use with the system arrangement of Figure 1;

Figure 3 is a flow diagram of a method constituting the embodiment of the invention, and

Figure 4 is a flow diagram showing a step of the method of Figure 3 in more detail.

In a secure broadcast system 100, a transmitter unit 102 coupled to a transmitter antenna 104 provides a received signal broadcast service within a coverage area 106 to a mobile terminal 108 via a radio-frequency (RF) interface 110.

The transmitter unit 102 and the transmitter antenna 104 are, in this example, fixed. However, the transmitter unit 102 and the transmitter antenna 104 need not necessarily be fixed at a single location, but the mobile terminal 108 must have knowledge of the location of the transmitter unit 102/ transmitter antenna 104, for example, by means of the transmitter 102 broadcasting its location to the mobile terminal 108, or the mobile terminal 108 knowing the itinerary of the movements of transmitter unit 102/ transmitter antenna 104. Similarly, the mobile terminal 108 need not be mobile and can be located at a fixed location. The mobility of the transmitter unit 102 and the mobile terminal 108 is not central to the invention, rather the fact that a service provider delivering the received signal service does not know the location of the terminal 108 is important.

Referring to Figure 2, the mobile terminal 108 comprises a radio receiver unit 200 coupled to a receiver antenna 202, and interfaced with a processor 204. Radio receiver units of the type used in conjunction with the above example are generally known in the art, and any suitable radio receiver unit, for example a High Frequency (HF) broadcast receiver, can be used provided that the radio receiver unit 200 is capable of receiving the received signal service broadcast by the transmitter unit 102.

The processor 204 is coupled to a memory 206, a first storage device 208, for example, a first disk drive, and a second storage device 210, for example, a second disk drive. The first and second storage devices 208, 210 are provided in order to store duplicate records, the purpose of which will be become apparent later.

The processor 204 is also coupled to an input/output (I/O) port 212 for downloading and uploading data from and to the memory 206, respectively. The processor 204, the memory 206, the first storage device 208, the second storage device 210 and the I/O port 212 can be part of a Personal Computer (PC). The processor 204 is interfaced with a positioning unit 214, for example, a Global Positioning System (GPS) receiver. Although, in the present example, a GPS receiver is being employed, it is envisaged that other means for determining the position of the mobile terminal 108 can be used in conjunction with, or as an alternative to, the GPS receiver.

A propagation model which is trusted by both the user and the service provider is stored in the memory 206 of the mobile terminal 108. The propagation model is a software tool which allows the prediction of received signal strengths at a given position in a geographical area using information stored in a database. The information stored in the database relates to certain factors which effect the propagation of radio waves in the path between a given transmitter and a given

receiver, for example, the condition or height of the ionosphere, the intervening geology between the given transmitter and the given receiver. The above factors vary in time. An example of one such propagation model is ACE supplied by Longwave, Inc.

In operation (Figure 3), the mobile terminal 108 moves within the coverage area 106. At a given time, a user of the mobile terminal 108 needs to receive the received signal service broadcast by the transmitter unit 102.

Consequently, the user activates the mobile terminal 108. The activation process can include powering-up the mobile terminal 108, and/or any other series of operations necessary to ensure that the mobile terminal 108 has entered a mode where it can attempt to receive the received signal service, for example, tuning to a correct frequency or deploying the receive antenna 202. However, such operations are well known in the art and do not concern the invention and so will not be described further.

Once activated, the processor 204 determines (step 302) the location of the mobile terminal 108 using information generated by the positioning unit 214 and then executes (step 300) the propagation model stored in the memory 206

The processor 204 then, using the propagation model, generates (step 304) an "ability" indication corresponding to whether or not the mobile terminal 108 should be able to receive the received signal service based upon knowledge of the location of the antenna 104, the location of the mobile terminal 108. Referring to Figure 4, the processor 204 generates the "ability" indication as follows.

Using the propagation model, a receive signal power, noise power, co-channel interference power, and adjacent channel interference power at the receive antenna 202 are predicted (step 400). Using an agreed characterisation of the mobile terminal 108 and the above power predictions, a prediction of the Bit Error Rate (BER) at the output of the radio receiver 200 can be obtained (step 402).

The radio receiver 200 is adapted to generate an estimation of the BER of the data output of the radio receiver 200 (step 404) which is compared (step 406) with the predicted BER. The "ability" indication is the result of the comparison of the predicted BER with the estimated BER. Although, in this example, the radio receiver 200 has been adapted to estimate the BER, estimation of the BER can be made elsewhere in the mobile terminal 108, for example, by the processor 204.

Referring back to Figure 3, the "ability" indication, the quality of reception, (optionally) the time of reception, and the predicted and estimated BERs are stored (step 306) in the first and second storage devices 208, 210 and are not confidential, or secret, and can be retrieved at a later time for use by both the user and the service provider in order to verify the user's ability to receive the received signal service at the undisclosed location.

In another embodiment of the invention, a plurality of transmitters exist which are capable of transmitting signals at respective frequencies close to that of the received signal service to the mobile terminal 108. The mobile terminal 108 is arranged to measure signal power of signals received from each of the plurality of transmitters in a predetermined band. The signal powers of the signals received from a number of the plurality of transmitter are also predicted using the propagation model. The predicted and measured signal powers are compared in order to determine a level of confidence in the radio receiver 200 and antenna 202, or at least one of the transmitters. For example, if the power levels of a large number of the signals received from the plurality of transmitters are unexpectedly low, then the mobile terminal 108 alerts and records that the radio receiver 200 or antenna 202 may not be operating correctly. Alternatively, if the measured power levels of most of the plurality of transmitters, other than a transmitter from which signal receipt by the mobile terminal 108 is wanted, are substantially in accordance with the predicted power levels, this would indicate that the

transmitter from which signal receipt is wanted is not operating correctly, for example, the transmitter may not be transmitting at its usual power level.

The above method and apparatus have been described for exemplary purposes only and it should be understood that variations and modifications of the above examples within the scope of the appended claims are possible.

CLAIMS

1. A method of verifying the ability of a first terminal, at an undisclosed location, to receive a signal transmitted from a second terminal, the method comprising the step of: determining the location of the first terminal at the location of the first terminal, generating data corresponding to an indication as to whether or not the first terminal should be able to receive the signal based upon the location determined at the location of the first terminal, a location of the second terminal and a propagation model corresponding to the communications link between the first and second terminals.

2. A method as claimed in Claim 1, wherein the data corresponding to an indication as to whether or not the first terminal should be able to receive the signal is generated by comparing a predicted Bit Error Rate (BER) with an estimated BER for the signals received at the first terminal.

3. A method as claimed in Claim 2, further comprising generating at least one predicted power level using the propagation model and generating, using the at least one power level, the predicted Bit Error Rate (BER) for the signal received at the first terminal.

4. A method as claimed in any one of the preceding claims, further comprising determining the location of the first terminal using a Global Positioning System (GPS) receiver.

5. A method as claimed in any one of the preceding claims, wherein a plurality of additional terminals are each capable of transmitting a respective additional

signal to the first terminal, the method further comprising identifying potential incorrect operation of the first terminal by: measuring respective signal power levels of at least a number of the respective additional signals transmitted by the plurality of additional terminals, predicting respective signal power levels of the at least number of the respective additional signals, and comparing the measured respective signal power levels with the predicted respective signal power levels.

6. A method as claimed in any one of Claims 1 to 4, wherein a plurality of additional terminals are each capable of transmitting a respective additional signal to the first terminal, the method further comprising identifying potential incorrect operation of the second terminal by: measuring respective signal power levels of a number of the respective additional signals transmitted by the plurality of additional terminals and the signal transmitted by the second terminal, predicting respective signal power levels of the number of the respective additional signals and the signal transmitted by the second terminal, and comparing the measured respective signal power levels with the predicted respective signal power levels.

7. An apparatus for verifying the ability of a first terminal, at an undisclosed location, to receive a signal transmitted from a second terminal, the apparatus comprising location means for determining the location of the first terminal at the location of the first terminal, and data generating means for generating data corresponding to an indication as to whether or not the first terminal should be able to receive the signal based upon the location determined by the first terminal, a location of the second terminal and a propagation model corresponding to the communications link between the first and second terminals.

8. An apparatus as claimed in Claim 7, wherein the data generating means is arranged to generate the data corresponding to an indication as to whether or not the first terminal should be able to receive the signal by comparing a predicted Bit Error Rate (BER) with an estimated BER for the signals received at the first terminal.

9. An apparatus as claimed in Claim 7, further comprising means for generating at least one predicted power level using the propagation model and generating, using the at least one power level, the predicted Bit Error Rate (BER) for the signal received at the first terminal.

10. An apparatus as claimed in any one of Claims 7 to 9, wherein a plurality of additional terminals are each capable of transmitting a respective additional signal to the first terminal, the apparatus further comprising means for identifying potential incorrect operation of the first terminal by measuring respective signal power levels of at least a number of the respective additional signals transmitted by the plurality of additional terminals, means for predicting respective signal power levels of the at least number of the respective additional signals, and means for comparing the measured respective signal power levels with the predicted respective signal power levels.

11. An apparatus as claimed in any one of Claims 7 to 9, wherein a plurality of additional terminals are each capable of transmitting a respective additional signal to the first terminal, the apparatus further comprising means for identifying potential incorrect operation of the second terminal by measuring respective signal power levels of a number of the respective additional signals transmitted by the plurality of additional terminals and the signal transmitted by the second terminal,

means for predicting respective signal power levels of the number of the respective additional signals and the signal transmitted by the second terminal, and means for comparing the measured respective signal power levels with the respective predicted signal power levels.

12. An apparatus as claimed in any one of Claims 7 to 11, wherein the location means is a Global Positioning System (GPS) receiver.

13. A method of diagnosing incorrect operation in a system comprising a receiving terminal capable of receiving a respective signal from each of a plurality of transmitting terminals, the method comprising identifying potential incorrect operation of the receiving terminal or at least one of the transmitting terminals by measuring respective signal power levels of the respective signals transmitted by a number of the plurality of transmitting terminals, predicting respective signal power levels of the respective signals of the number of the plurality of transmitting terminals, and comparing the measured respective signal power levels with the predicted respective signal power levels.

14. An apparatus for verifying the ability of a first terminal, at an undisclosed location, to receive a signal transmitted from a second terminal substantially as hereinbefore described with reference to Figures 1 and 2.

15. A method of verifying the ability of a first terminal, at an undisclosed location, to receive a signal transmitted from a second terminal substantially as hereinbefore described with reference to Figures 3 and 4.

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Application No:	GB 9921797.8	**Examiner:**	Glyn Hughes
Claims searched:	1 to 12, 14, 15	**Date of search:**	16 March 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H4L (LFMA, LFMB, LFMX)

Int Cl (Ed.7): H04Q 7/36

Other: Online: WPI, JAPIO, EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2261139 A	(SECURITY SERVICES) see whole document	-
A, E	WO 99/59363 A1	(CARNEGIE MELLON) see whole document	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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